

CLAIMS

What is claimed is:

- 1 1. A method of forming an embedded read element, comprising:
2 performing a photolithographic patterning step for defining a designed height of
3 an embedded read element on a wafer, wherein the definition of the height
4 of the embedded read element also results in formation of an in-line
5 lapping guide with a spacing formed between the embedded read element
6 and the in-line lapping guide;
7 performing a further photolithographic patterning step for defining a designed
8 width of the embedded read element;
9 performing a further photolithographic patterning step for connecting the
10 embedded read element and the in-line lapping guide with conducting
11 layers;
12 performing a first mechanical lapping step on the wafer, wherein the first
13 mechanical lapping step is monitored by measuring the resistance of a
14 parallel circuit of the embedded read element and the in-line lapping
15 guide; and
16 performing a second mechanical lapping step on the wafer, wherein the second
17 mechanical lapping step is monitored by measuring the GMR response of
18 the embedded read element.

1 2. A method as recited in claim 1, wherein the read element is an embedded giant
2 magnetoresistance (GMR) sensor used in a current-in-plane (CIP) mode.

1 3. A method as recited in claim 2, wherein the embedded giant magnetoresistance
2 (GMR) sensor comprises:
3 a nonmagnetic seed layer;
4 ferromagnetic sense layers;
5 a nonmagnetic spacer layer;
6 a ferromagnetic reference layer;
7 a nonmagnetic antiparallel (AP) exchange-coupling layer;
8 a ferromagnetic keeper layer; and
9 a nonmagnetic cap layer.

1 4. A method as recited in claim 3, wherein the embedded giant magnetoresistance
2 (GMR) sensor further comprises an antiferromagnetic pinning layer sandwiched
3 into the keeper and cap layers.

1 5. A method as recited in claim 3, wherein the embedded giant magnetoresistance
2 (GMR) sensor comprises:
3 a nonmagnetic Ni-Cr-Fe seed layer;
4 ferromagnetic Ni-Fe/Co-Fe sense layers;
5 a nonmagnetic Cu-O spacer layer;
6 a ferromagnetic Co-Fe reference layer;

7 a nonmagnetic Ru antiparallel (AP) exchange-coupling layer;
8 a ferromagnetic Co-Fe keeper layer; and
9 nonmagnetic Cu and Ta cap layers.

1 6. An embedded GMR sensor as recited in claim 5, further comprising an
2 antiferromagnetic Pt-Mn pinning layer sandwiched into the Co-Fe keeper and Cu
3 cap layers.

1 7. A method as recited in claim 1, wherein the read element is an embedded giant
2 magnetoresistance (GMR) sensor used in a current-perpendicular-to-plane (CPP)
3 mode.

1 8. A method as recited in claim 7, wherein the embedded giant magnetoresistance
2 (GMR) sensor comprises:
3 a nonmagnetic seed layer;
4 ferromagnetic sense layers;
5 a nonmagnetic spacer layer;
6 a ferromagnetic reference layer;
7 a nonmagnetic antiparallel (AP) exchange-coupling layer;
8 a ferromagnetic keeper layer; and
9 a nonmagnetic cap layer.

1 9. A method as recited in claim 8, wherein the embedded GMR sensor further
2 comprises an antiferromagnetic pinning layer sandwiched into the keeper and cap
3 layers.

1 10. A method as recited in claim 7, wherein the embedded GMR sensor comprises:
2 a nonmagnetic seed layer;
3 ferromagnetic sense layers;
4 a nonmagnetic spacer layer;
5 a ferromagnetic reference layer;
6 a nonmagnetic antiparallel (AP) exchange-coupling layer;
7 a ferromagnetic keeper layer; and
8 a nonmagnetic cap layer.

1 11. A method as recited in claim 10, wherein the embedded GMR sensor further
2 comprises an antiferromagnetic pinning layer sandwiched into the keeper and cap
3 layers.

1 12. A method as recited in claim 1, wherein the read element is an embedded
2 tunneling magnetoresistance (TMR) sensor used in a current-perpendicular-to-
3 plane (CPP) mode.

1 13. A method as recited in claim 12, wherein the embedded TMR sensor comprises:
2 a nonmagnetic seed layer;

- 3 ferromagnetic sense layers;
- 4 a nonmagnetic barrier layer;
- 5 a ferromagnetic reference layer;
- 6 a nonmagnetic antiparallel (AP) exchange-coupling layer;
- 7 a ferromagnetic keeper layer; and
- 8 a nonmagnetic cap layer.

1 14. A method as recited in claim 13, wherein the embedded TMR sensor further
2 comprises an antiferromagnetic pinning layer sandwiched into the keeper and cap
3 layers.

1 15. An embedded read element as recited in claim 12, which is an embedded
2 tunneling magnetoresistance (TMR) sensor used in a current-perpendicular-to-
3 plane (CPP) mode, comprising:
4 a nonmagnetic Ta seed layer;
5 ferromagnetic Ni-Fe/Co-Fe sense layers;
6 a nonmagnetic Al-O barrier layer;
7 a ferromagnetic Co-Fe reference layer;
8 a nonmagnetic Ru antiparallel (AP) exchange-coupling layer;
9 a ferromagnetic Co-Fe keeper layer; and
10 nonmagnetic Cu and Ta cap layers.

1 16. A method of forming an embedded read element, comprising:

2 performing a photolithographic patterning step for defining a designed height of
3 an embedded read element on a wafer, wherein the definition of the height
4 of the embedded read element also results in formation of an in-line
5 lapping guide with a spacing formed between the embedded read element
6 and the in-line lapping guide;
7 performing a further photolithographic patterning step for defining a designed
8 width of the embedded read element;
9 performing a first mechanical lapping step on the wafer; and
10 performing a second mechanical lapping step on the wafer.

1 17. A method as recited in claim 16, further comprising performing a further
2 photolithographic patterning step for connecting the embedded read element and
3 the in-line lapping guide with conducting layers;

1 18. A method as recited in claim 16, wherein the first mechanical lapping step is
2 monitored by measuring the resistance of a parallel circuit of the embedded read
3 element and the in-line lapping guide.

1 19. A method as recited in claim 16, wherein the second mechanical lapping step is
2 monitored by measuring the GMR response of the embedded read element.

1 20. An embedded read element, comprising:
2 a read element having been formed according to the following method:

3 performing a photolithographic patterning step for defining a designed height of
4 an embedded read element on a wafer, wherein the definition of the height
5 of the embedded read element also results in formation of an in-line
6 lapping guide with a spacing formed between the embedded read element
7 and the in-line lapping guide;
8 performing a photolithographic patterning step for defining a designed width of
9 the embedded read element;
10 performing a further photolithographic patterning step for connecting the
11 embedded read element with conducting layers;
12 performing a first mechanical lapping step on the wafer, wherein the mechanical
13 lapping step is monitored by measuring the resistance of a parallel circuit
14 of the embedded read element and the in-line lapping guide;
15 performing a second mechanical lapping step on the wafer, wherein the second
16 mechanical lapping step is monitored by measuring the GMR response of
17 the embedded read element.

1 21. A magnetic disk drive, comprising:
2 a magnetic disk;
3 a slider having a magnetic head assembly including write and read heads for
4 writing to and reading data from the magnetic disk is mounted, wherein
5 the read head includes an embedded read element formed by the process
6 recited in claim 1;
7 a suspension arm supporting the slider; and

8 an actuator arm coupled to the suspension arm.